Solid Hydrogen Particles Analyzed for Atomic Fuels

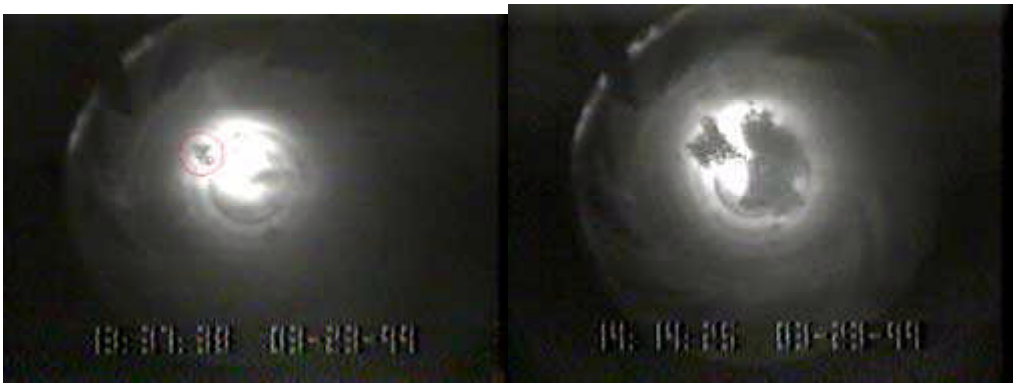
Solid hydrogen particles have been selected as a means of storing atomic propellants in future launch vehicles (refs. 1 to 2). In preparation for this, hydrogen particle formation in liquid helium was tested experimentally.

These experiments were conducted to visually characterize the particles and to observe their formation and molecular transformations (aging) while in liquid helium. The particle sizes, molecular transformations, and agglomeration times were estimated from video image analyses.

The experiments were conducted at the NASA Glenn Research Center in the Supplemental Multilayer Insulation Research Facility (SMIRF, ref. 3). The facility has a vacuum tank, into which the experimental setup was placed. The vacuum tank prevented heat leaks and subsequent boiloff of the liquid helium, and the supporting systems maintained the temperature and pressure of the liquid helium bath where the solid particles were created.

As the operation of the apparatus was developed, the hydrogen particles were easily visualized. The figures (ref. 1) show images from the experimental runs. The first image shows the initial particle freezing, and the second image shows the particles after the small particles have agglomerated. The particles finally all clump, but stick together loosely. The solid particles tended to agglomerate within a maximum of 11 min, and the agglomerate was very weak. Because the hydrogen particles are buoyant in the helium, the agglomerate tends to compact itself into a flat pancake on the surface of the helium. This pancake agglomerate is easily broken apart by reducing the pressure above the liquid. The weak agglomerate implies that the particles can be used as a gelling agent for the liquid helium, as well as a storage medium for atomic boron, carbon, or hydrogen.

The smallest particle sizes that resulted from the initial freezing experiments were about 1.8 mm. About 50 percent of the particles formed were between 1.8 to 4.6 mm in diameter. These very small particle sizes are encouraging for future formation experiments, where simpler operations will reduce the costs of production.



Left: Solid hydrogen particles floating on the surface of a liquid helium bath. A small number of frozen particles have clumped together. Right: Solid hydrogen particles after they have all clumped together. The particle clumping process took up to 11 min.

The particle freezing process was completed almost immediately after the hydrogen fell onto the liquid helium surface, and the molecular structure of the hydrogen tended to change from a face-centered-cubic to a hexagonal-close-packed structure within 1 min. This transition must be con-trolled to allow the deposition of atoms into the solid particles. Further analysis of the images is needed to more fully understand the particle formation and to better understand the structural transition in such small particles.

Find out more about our research with fuels and space propellants (http://sbir.grc.nasa.gov/launch/foctopsb.htm).

References

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